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Application Note:
Energy Meter Evaluation Module

PM2002DP

INTRODUCTION

This application note describes the functionality of the SA2002D metering integrated circuit using the PM2002DP evaluation module.

The SA2002 enables the meter manufacturer to build a meter that measures the energy consumption, and records it to a mechanical counter. Energy flow direction as well as energy metering activity is indicated by means of LEDs. This application note will focus on the practical use of the SA2002D, more detailed information specific to the SA2002D can be found in the applicable datasheet.

THE SA2002D PIN PROGRAMMABLE MONOCHIP METER

Setting	Calibrated LED imp/kWh	Pin Status
6A / 220V	6400	R0 = 0, R1 = 0, R2 = 1
10A / 220V	6400	R0 = 0, R1 = 0, R2 = 0
20A / 220V	3200	R0 = 1, R1 = 0, R2 = 0
30A / 220V	3200	R0 = 1, R1 = 0, R2 = 1
40A / 220V	1600	R0 = 0, R1 = 1, R2 = 0
60A / 220V	1600	R0 = 0, R1 = 1, R2 = 1
80A / 220V	800	R0 = 1, R1 = 1, R2 = 0

Table 1: A summary of the pin settings possible with the SA2002D. Pin status 0 indicates connection to VSS and 1 indicates connection to VDD.

CONNECTORS ON MODULE

The PM2002DP module connects directly to live and neutral on SCK1. The module is referenced to live and should be kept in mind when connecting test equipment to the module. The current is measured by the shunt on the top of the PCB. The left terminal of the shunt is connected to live. The live out will be connected to the right terminal of the shunt.

Name	Function Description
SCK1	Mains connector for module power and voltage sense
JP2	Optional current transformer connector. (Underneath shunt resistor)
JP3	Optional Stepper motor connector. (Remove jumper J6 to disconnect impulse counter)

Table 2: Connector descriptions

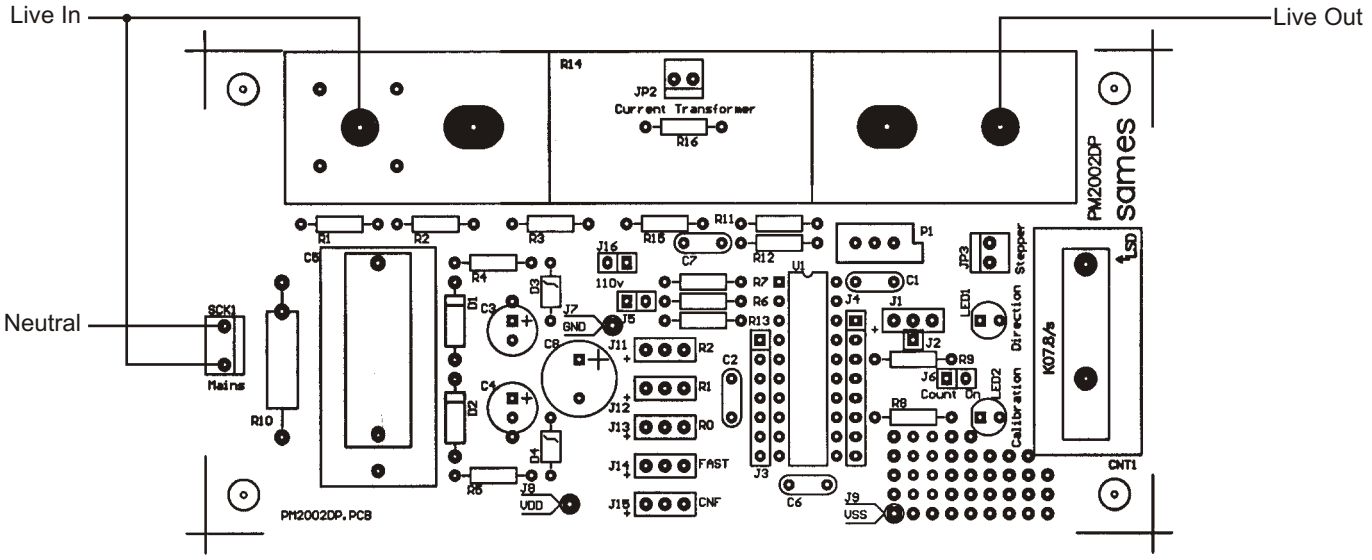

Figure 1: Connection and jumper settings for 80A / 220V bi-directional meter module

MODULE SETUP

The PM2002DP module is setup for use with the SA2002D integrated circuit. Resistor values used on the module are calculated for rated conditions of 80A/220V.

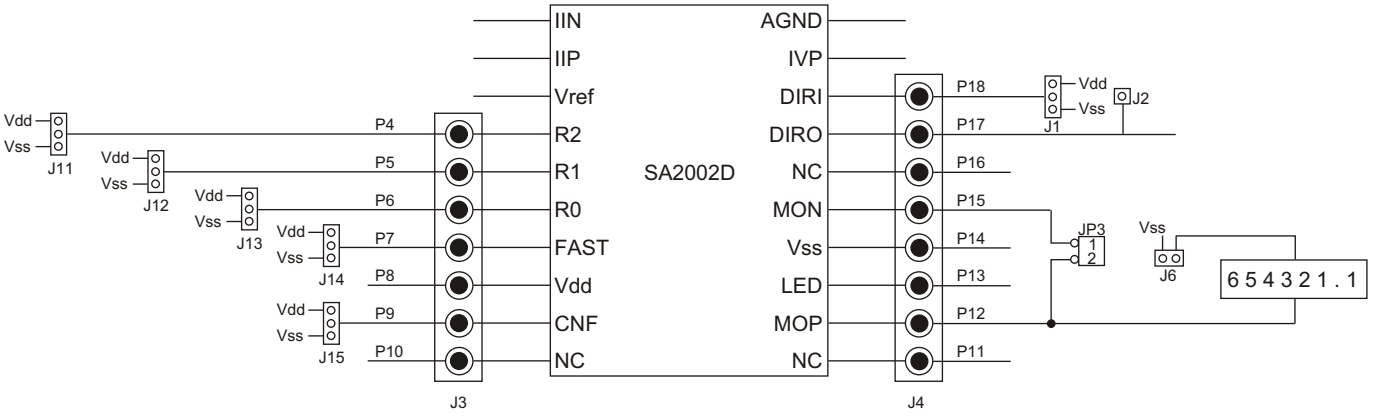

Figure 2: Jumper schematic, digital IO's

Name	Function Description
J1	J1 is used to select the energy direction (DIRI pin). The three options available are: P18 connected to Vdd - Negative energy measurement P18 connected to Vss - Positive energy measurement P18 connected to J2 (P17) - Bi-directional energy measurement P18 should not be left floating and must be connected to one of the options described above.
J2	J2 is only used to select bi-directional energy measurement when connected to P18
J3 and J4	These are test points placed next to the digital pins of the SA2002E
J5	Not fitted This is the current sense input ground. If a current transformer is used for current sensing the two pins of J5 must be connected.
J6	Connects the impulse to VSS. If a stepper motor is connected to JP3 then J6 should be left open.
J7	Analog ground test point (see figure 1)
J8	Positive supply test point (Vdd) (see figure 1)
J9	Negative supply test point (Vss) (see figure 1)
J11, J12 and J13	Used to select the R2, R1 and R0 pins of the SA2002D for the various rated conditions. Refer to table 1 for the possible settings
J14	Used to select fast calibration mode. Connecting P7 to Vdd selects fast calibration mode. For normal operation P7 must be connected to Vss
J15	Used to select between normal and configure / test modes. For normal operation connect P9 to Vss.
J16	Used to select between 220V and 110V mains systems (See figure 3). Leave open for 220V mains.

Table 3: Jumper settings for various device options

ANALOG SECTION

The analog (metering) interface described in this section is designed for measuring 220V/80A with precision better than Class 1.

The most important external components for the SA2002D integrated circuit are the current sense resistors, the voltage sense resistors and the bias setting resistor. The resistors used in the metering section should be of the same type so temperature effects are minimized.

Voltage Input IVP

The voltage input of the SA2002D (IVP) is driven with a current of 14µA at nominal mains voltage. This voltage input saturates at approximately 17µA. At a nominal voltage current of 14µA allows for 20% overdriving. The mains voltage is divided with a voltage divider to 14V that is fed to the voltage input pins via a 1M resistor

Voltage Divider

The voltage divider is (Figure 3) calculated for a voltage drop of 14V. Treat C7 as a short circuit and ignore J16. Equations for the voltage divider in figure 3 are:

RB = R1 + R2 + R3 + R15 + R10
RB = R12 || (R11 + P1 / 2)

Combining the two equations gives:
(RA + RB) / 220V = RB / 14V

Values for resistors R10 = 47 , R11 = 22k , P1=10k and R12 = 1M is chosen.

Substituting the values result in:
RB = 26.29k
RA = RB x (220V / 14V - 1)
RA = 386.84k

Standard resistor values of R1, R2, R3 and R15 are chosen to be 47k , 150k , 47k and 150k . The resistor RA is divided so that the voltage drop across one resistor is within the specified limits of the resistor type that is used, usually 200VDC. The resistor value ratios are chosen so that shorting J16 the module could be used on a 110VAC mains system.

CURRENT SENSOR INPUT RESISTORS FIGURE 4 (USING A SHUNT RESISTOR)

The resistors R6, R7 define the current level into the current sense inputs the device. The voltage drop across the shunt should be at least 20mV at rated conditions. A shunt resistor with a value of 50mV @80A was chosen for the application module for its ease of use. The resistor values are calculated for an input current of 16µA on the current inputs at rated conditions. For a 80A meter the resistor values are calculated as follows:

$R6 = R7 = (I_L / 16\mu A) \times R_{SH} / 2$
$= 80A / 16\mu A \times 625u / 2$
$= 1.5625k$

I_L = Line current

A standard value of 1.6k is chosen.

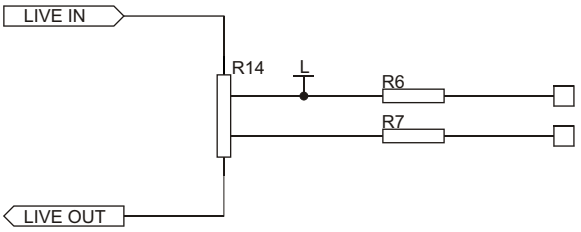

Figure 4: Current input configuration

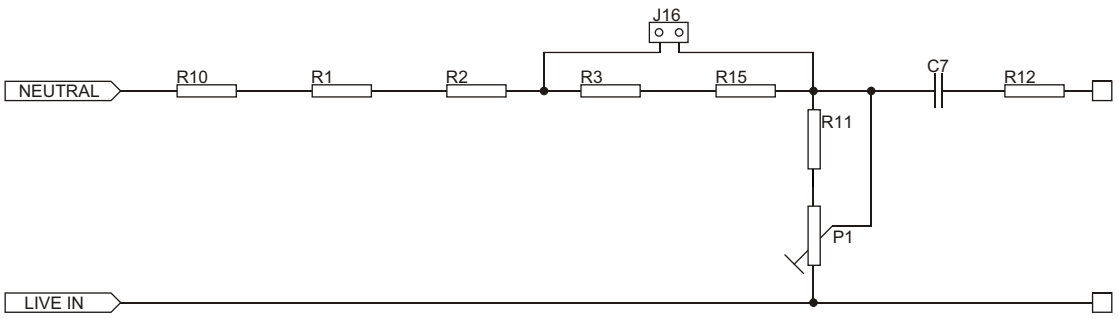

Figure 3: Mains voltage divider

CT TERMINATION RESISTOR

Provision is made for the use of a current transformer on the module. The existing shunt needs to be removed and the current sense resistors will have to be recalculated for the specific current transformer. The voltage drop across the CT termination resistor at rated current should be at least 20mV. The CT's used should have a low phase shift and a ratio of 1:2500.The CT is terminated with a 2.7 resistor giving a voltage drop of 864mV across the termination resistor at rated conditions

CURRENT SENSOR INPUT RESISTORS FIGURE 5 (USING A CURRENT TRANSFORMER)

The resistors R6, R7 define the current level into the current sense inputs the device. The resistor values are selected for an input current of 16µA on the current inputs at rated conditions. For an 80A-rated meter the resistor values are calculated as follows:

$R6 = R7 = (I_L / 16\mu A) \times R_{SH} / 2$
$= 80A / 16\mu A \times 2.7 / 2$
$= 2.7k$

$I_{L=}$ Line current
RSH = CT Termination resistor
2500 = CT ratio

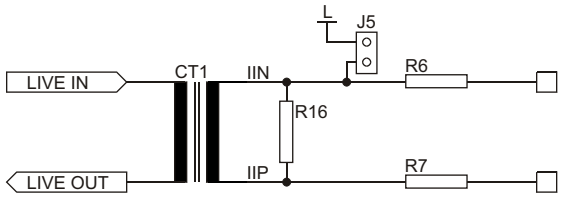

Figure 5: Current input configuration

Phase Compensation (When using a current transformer)

Phase shift caused by the current transformer may be corrected by inserting a capacitor in the voltage divider circuit. See Figure 6, Capacitor C7. To compensate for a phase shift of 0.18 degrees the capacitor value is calculated as follows:

C = 1 / (2 x x Mains frequency x R5 x tan (Phase shift angle))
C = 1 / (2 x x 50 x 1M x tan(0.18 degrees))
C = 1.013µF

Reference Voltage VREF

The VREF pin of the SA2002D is connected to a resistor that determines the on chip bias current.

Ground GND

The GND pin of the SA2002D is to the live phase, which is halfway between VDD and VSS. Note that supply bypass capacitors C1 and C2 are positioned as close as possible to the supply pins of the device, and connected to a solid ground plane.

COMPONENT LISTS

The following component list covers all components fitted on the PM2002DP module as shipped

Symbol	Description	Detail
U1	SA2002D	DIP-20
D1, D2	Diode, Silicon, 1N4007	
D3, D4	Diode, Zener, 2.4V	
R1, R3	Resistor, 47k, 1/4W, 1%, metal	
R2, R15	Resistor, 150k, 1/4W, 1%, metal	
R4, R5	Resistor, 100R, 1/4W, 1%, metal	
R6, R7	Resistor, 1.6k, 1/4W, 1%, metal	Note 1
R8, R9	Resistor, 2.4k, 1/4W, 1%, metal	
R10	Resistor, 47R, 2W, 5%, wire wound	
R11	Resistor, 22k, 1/4W, 1%, metal	
R12	Resistor, 1M, 1/4W, 1%, metal	
R13	Resistor, 24k, 1/4W, 1%, metal	
R14	Shunt resistor, 80A / 50mV	
R16	Resistor, 1/4W, 1%, metal	Note 1
P1	Resistor, 1/4W, 1%, metal	
C1, C2	Capacitor, 220nF	
C3, C4	Capacitor, 220nF, 16V, electrolytic	
C5	Capacitor, 470nF, 250VAC	
C6	Capacitor, 820nF	
C7	Capacitor	Note 2
C8	Capacitor, 2200uF, 16V, electrolytic	
LED1, LED2	3mm Light emitting diode	
CNT1	Impulse counter, Kuebler, K07.80	
SCK1	Molex 3 pin connector, 200mil pin spacing	
JP3	Molex 2 pin connector, 100mil pin spacing	
6	Jumpers	
24	Header pins	

Note1: In case a current transformer is used on the board R16 is the termination resistor. Resistors R6 and R7 values may need to be changed to match the CT used.

Note2: Capacitor values may be selected to compensate for phase errors caused by current transformers.

Table 4: Components for PM200DP module set up for 220V/80A

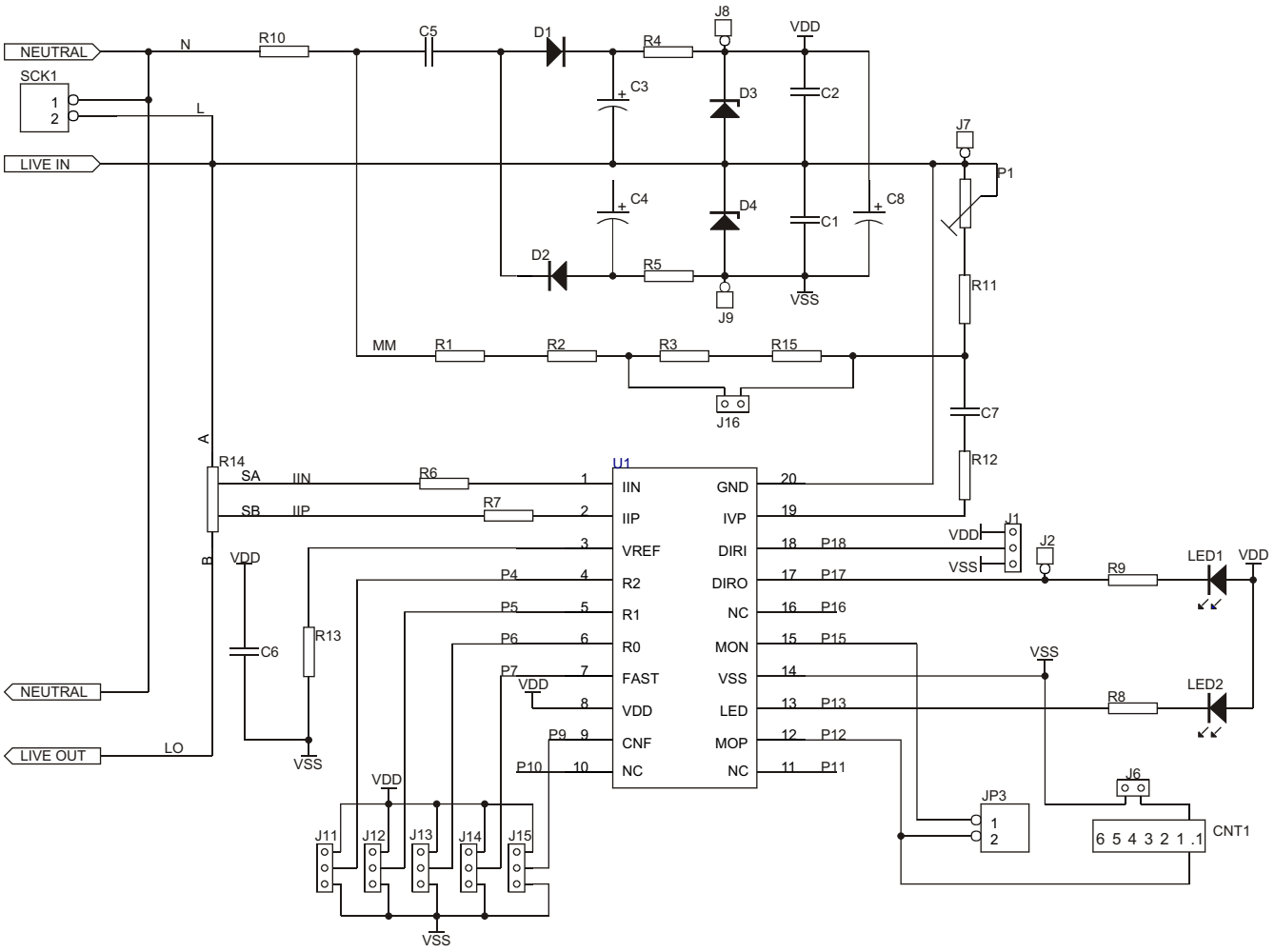

Figure 6: Schematic diagram of the complete PM2002DP module

PCB LAYOUT

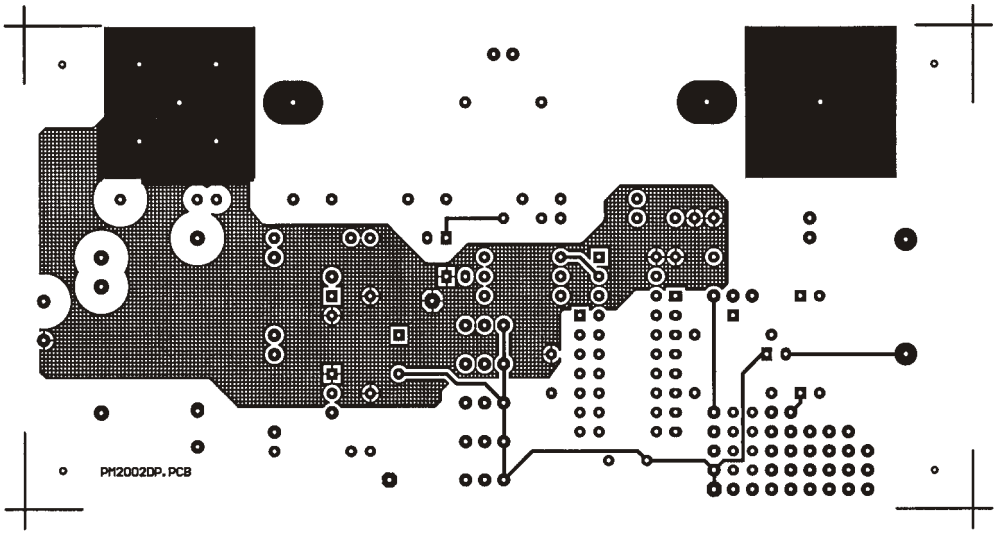

Figure 7: Top layer layout of the PM2002D module

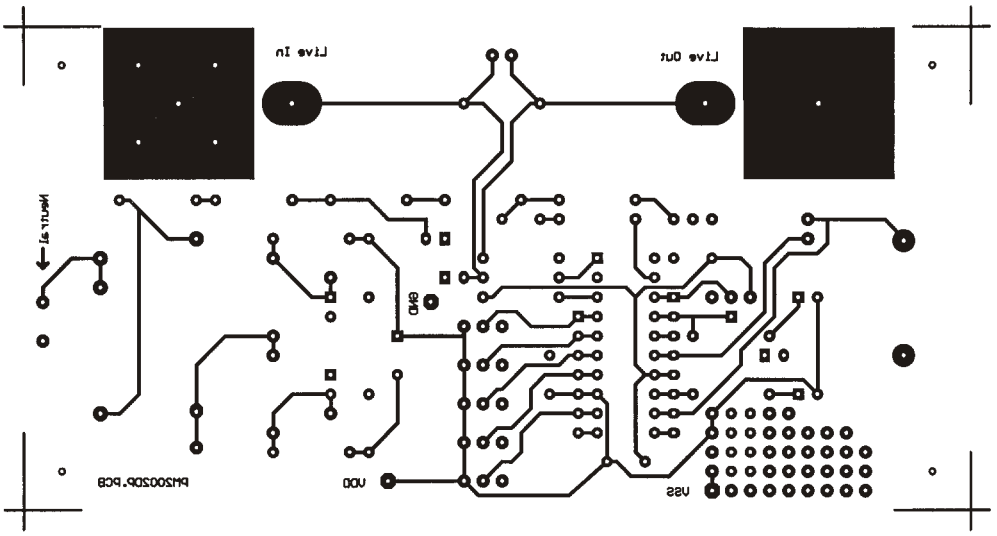

Figure 8: Bottom layer layout of the PM2002D module

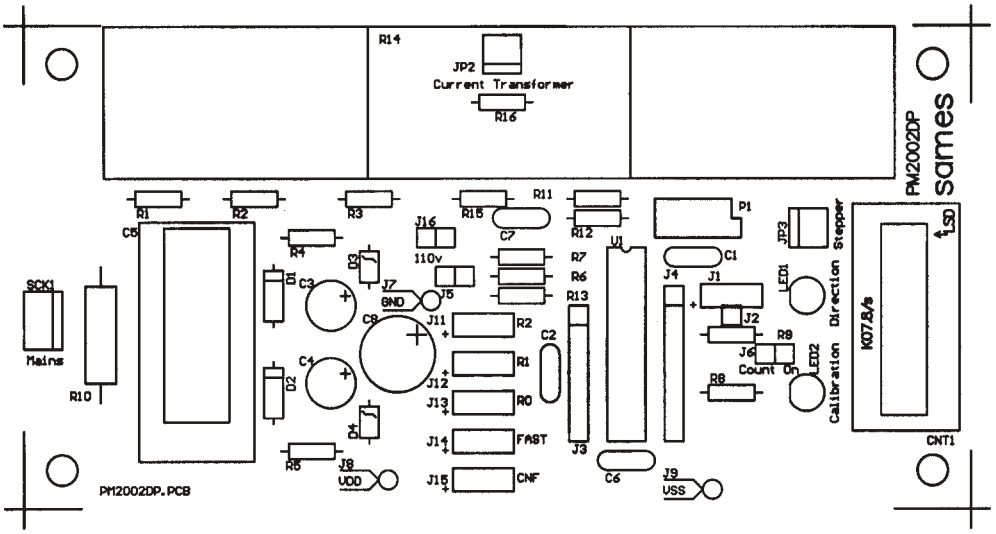

Figure 9: Silkscreen of the PM2002D module

NOTE:

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